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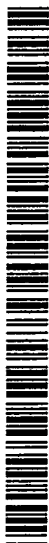


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(54) Title: METHOD OF REMOVAL OF IMPURITIES FROM GOLD CONCENTRATE CONTAINING SULFIDES

(57) Abstract: The present invention focuses on the method for the removal of impurities, such as tellurium and bismuth, from gold concentrate containing sulfides. According to the present method, the impurities are leached from the gold concentrate with the aid of an acidic aqueous solution, at an elevated temperature, whereby the impurities dissolve and the gold remains in the concentrate.

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## **METHOD OF REMOVAL OF IMPURITIES FROM GOLD CONCENTRATE CONTAINING SULFIDES**

The present invention focuses on the method of the removal of impurities, such as tellurium and bismuth, from gold concentrate containing sulfides. According to the present method, the impurities are dissolved from the gold concentrate with the aid of an acidic aqueous solution, at an elevated temperature, whereby the impurities dissolve and the gold remains in the concentrate.

The gold in the gold concentrate containing sulfides appears as metallic or telluride. Additionally, in general the valuable materials present in the concentrate are iron and copper, as well as small amounts of lead and zinc, all of which are sulfides. The impurities bismuth and tellurium appear together as bismuth telluride.

In order to recover the gold, the gold concentrate can be leached by cyanide leaching, but the disadvantage here is the long leaching time and in addition, the gold recovery is only 80% at best.

It is also possible to treat the gold concentrate simultaneously with the copper concentrate, whereby it is conveyed firstly to pyrometallurgical processing, where the gold passes with the copper all the way to the cast copper anodes. The gold in copper electrolysis remains in the so-called anode sludge, from which gold recovery is a separate process. In addition to gold, other metals, which are harmful in the copper refining process, may be present in the gold concentrate. Such metals are, for instance, bismuth and tellurium, which are particularly harmful in copper electrolysis, as their removal is problematic. Thus copper manufacturers are not willing to accept tellurium-containing concentrates.

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Now, a method has been developed for the removal of impurities such as bismuth and tellurium from gold concentrate containing sulfides, whereby the impurities in the concentrate are leached, at an elevated temperature, into an acidic aqueous solution. The use of an oxydising agent improves the recovery of impurities into the solution. The elevated temperature means a temperature above the ambient temperature, but the leaching takes place in atmospheric conditions. Dissolution reactions at room (ambient) temperature are too slow for sensible treatment of the concentrate and a beneficial temperature for the reaction is in the range of 50 - 80 °C. The essential features of the present invention are presented in the enclosed claims.

The acidic aqueous solution, whose pH is in the region of 0.5 – 1.5, optimally 1.0, can be formed from alkali or alkali earth chloride solution by the use of sulfuric acid or hydrochloric solution for pH-reducing. If silver is also present in the concentrate, it is beneficial to add sulfuric acid to the chloride solution, as the silver dissolves to a somewhat lesser extent in a chloride solution which contains some sulfate. The use of sole sulfuric acid solution can lead to more foaming than use of a pure chloride or chloride-sulfate solution. It can be beneficial to use for example, sodium chloride, NaCl, or correspondingly potassium, calcium or magnesium chloride as alkali or alkali earth chloride. To increase the effectiveness of the leaching it is also advantageous to use an oxydising agent, which could be for instance hydrogen peroxide,  $H_2O_2$ , or sodium chlorate. Bismuth dissolves almost totally already for example in alkali or alkali earth chloride solution having a concentration of 50 g/l, but for the leaching of tellurium it is beneficial to use a concentration of 70 – 300 g/l. It has been proved that, using the present method and in the appropriate leaching time, it is possible to separate over 90% of the bismuth and tellurium in the concentrate.

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Gold does not dissolve in the leaching but remains in the leach residue, which is filtered and carefully washed free of chloride. The leach residue, or washed concentrate, is easy to settle and filter and it can be treated in a smelter more economically than the original concentrate. The filtrate, containing metals, is conducted to neutralization, where the tellurium precipitates at a pH value of about 2 and bismuth at a pH value of about 4. Neutralization can be performed, for example with lye, lime, or other alkali. If the precipitation is performed with lime, the sulfate used in leaching is removed off as gypsum.

As other concentrate impurities have also dissolved from the concentrate during leaching, these can also be removed, in any case partly, from the concentrate at the precipitation stage. Thus iron, arsenium and antimony precipitate at the same pH as tellurium, lead precipitates with bismuth. Leaching enables the removal of about 2/3 of the amount of lead from the concentrate and about one third of the amount of arsenium. The precipitated solid matter is removed from the solution by filtration and, after the addition of acid, the solution can be taken back to the leaching stage.

The present invention is also described with the aid of the following examples:

#### Example 1

The gold concentrate was leached for the removal of bismuth and tellurium at different NaCl-concentrations and NaCl and sulfuric acid combinations at a pH value of 1 and at a temperature of 60 °C, according to tests 1-4, and at room temperature (25° C), test 5. The results are shown in Table 1. The table shows first the contents of the different metals of the concentrate, then the results of the tests made under the various conditions. In each test the concentrate was leached for 5 hours;

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the amount of metal dissolved can be seen in the table as a percentage of the amount of metal contained in the original concentrate, for every test, as a function of time.

As indicated in the table, from the total standpoint the most beneficial results were achieved with a concentration of 100g/l NaCl and when the pH value was kept at  $\leq 1.0$  with the aid of sulfuric acid.

Table 1

Conc.	Au	Ag	Bi	Te	Cu	As
	ppm	ppm	%	%	%	%
	312	41	0.77	0.83	0.18	0.07
<b>Test 1 NaCl 200 g/l, Temp. 60 C, Solubility, %</b>						
½ h	<0.5	43.9	78.5	80.4	4.3	23.9
1h	<0.5	70.9	97.8	93.7	5.5	4.7
2h	<0.5	70.9	98.5	77.3	5.8	15.2
3h	<0.5	68.9	93.9	82.3	6.2	23.3
5h	<0.5	70.9	98.5	84.1	6.8	25.1
<b>Test 2 NaCl 100 g/l, Temp. 60 C, Solubility, %</b>						
½ h	<0.5	32.1	70.1	54.7	4.7	24.4
1h	<0.5	55.8	98.7	56.1	6.3	6.3
2h	<0.5	65.3	95.9	71.3	7.7	9.5
3h	<0.5	63.2	94.2	86.8	7.8	22
5h	<0.5	62.2	98.4	85.7	8.1	22.9
<b>Test 3 NaCl 50 g/l, Temp. 60 C, Solubility, %</b>						
½ h	<0.6	15	48.1	37.1	3.5	28.3
1h	<0.6	50.5	93.8	51.5	6.2	9.4
2h	<0.6	40.4	98.3	67	6.3	9.7
3h	<0.6	30.3	85.8	77.5	7.9	20.1
5h	<0.6	35.3	93.3	84.4	6.7	20.1
<b>Test 4 NaCl 100 g/l, H2SO4, Temp. 60 C, Solubility, %</b>						
½ h	<0.6	32.7	75.8	59.8	4.6	26.1
1h	<0.6	59.9	98.3	69	5.6	14.6
2h	<0.6	65.4	98.9	82.9	6.3	21.6
3h	<0.6	43.6	91.4	80.5	6.3	23.6
5h	<0.6	43.6	90	82.6	6.4	23.9
<b>Test 5 NaCl 100 g/l, Ambient temp., Solubility, %</b>						
½ h	<0.1	1.6	14.3	9.8	1.2	22
1h	<0.1	3	16.1	12.8	1.4	24.3
2h	<0.1	8.9	18.2	14.7	1.7	23.1
3h	<0.1	11.5	20.3	16.7	1.9	23.7
5h	<0.1	12.3	22.9	18.9	1.9	24

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**Example 2**

In the solution obtained from the gold concentrate leaching, the pH of the solution was 0.6, the impurities were precipitated by the addition of lye, so that the pH was raised to the value of 2.0, then to the value of 4.0, after which to the value of 6.0 and finally to the value of 7.0. The results are presented in Table 2.

**Table 2**

Solution	pH	Bement	Au	Ag	Bi	Te	Cu	Pb	Fe	As
		Unit	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Startsol.	0,64		<1	16	3930	4130	66	195	6320	77
	2		<1	14	3200	650	57	180	1260	3
	4		<1	12	3	<1	66	6	610	1
	6,00		<1	13	1	<1	51	3	14	1
	7,02		<1	12	<1	<1	37	<1	1	<1

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## CLAIMS

1. A method for the removal of impurities such as tellurium and bismuth from gold concentrate containing sulfides, **characterized** in that impurities are leached from the gold concentrate in an acidic aqueous solution at an elevated temperature.
2. A method according to claim 1, **characterized** in that the elevated temperature is 50 - 80 °C.
3. A method according to claim 1, **characterized** in that the acidic aqueous solution is alkali or alkali earth chloride solution, where the amount of alkali or alkali earth chloride is at least 50g/l.
4. A method according to claim 3, **characterized** in that the acidic aqueous solution is alkali or alkali earth chloride solution, where the amount of alkali or alkali earth chloride is 50-300 g/l.
5. A method according to claim 3, **characterized** in that the acidic aqueous solution is NaCl solution, where the amount of NaCl is at least 50 g/l.
6. A method according to claim 1, **characterized** in that the aqueous solution is acidified with the aid of sulfuric acid.
7. A method according to claim 6, **characterized** in that the amount of sulfuric acid in the acidic aqueous solution is at least 10g/l.

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8. A method according to claim 1, characterized in that the aqueous solution is acidified with the aid of hydrochloric acid.
9. A method according to claim 8, characterized in that the amount of hydrochloric acid in the acidic aqueous solution is at least 10g/l.
10. A method according to claim 1, characterized in that an oxidizing agent is used in the leaching.
11. A method according to claim 10, characterized in that the oxidizing agent is hydrogen peroxide,  $H_2O_2$ .
12. A method according to claim 10, characterized in that the oxidizing agent is sodium chlorate.
13. A method according claim 1, characterized in that the pH of the acidic aqueous solution is 0.5 – 1.5.
14. A method according to claim 1, characterized in that after the removal of impurities the leach residue is washed, filtered and conducted to pyrometallurgical treatment.
15. A method according to claim 1, characterized in that the filtrate containing the impurities is neutralized in order to precipitate the impurities.
16. A method according to claim 15, characterized in that the filtrate, from which the impurities are precipitated, is conducted back to leaching.



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## INTERNATIONAL SEARCH REPORT

International application No.

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## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C22B 11/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C22B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5232490 A (FREDRICK N. BENDER ET AL), 3 August 1993 (03.08.93), column 34, line 10 - column 35, line 60, claim 38, abstract	1-10,13-16
Y	--	11,12
X	US 4378275 A (DAVID V. ADAMSON ET AL), 29 March 1983 (29.03.83), column 2, line 12 - line 15; column 13, line 61 - column 14, line 63, claims 1,2,6,7,31, abstract	1-5,8-10, 13-16
A	--	6,7,11,12

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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## INTERNATIONAL SEARCH REPORT

International application No.

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## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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